

# Length-weight models and condition factors of fishes from Okpara Stream, Oueme River, Northern-Benin

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**Abstract**— Length frequency distributions, length-weight models and condition factors of 21 dominant fish species of the Okpara stream (Oueme River) were examined in Northern-Benin in order to evaluate the well-being of these fish taxa. Samplings were made monthly from December 2015 to May 2017 with seines, gill nets, traps and a total of 9,302 individuals were collected. Fish abundance ranged from 53 individuals for *Mormyrus rume* to 2,818 for *Hemichromis fasciatus*. Standard length (SL) varied from 1.2 cm (*Coptodon guineensis*) to 51.8 cm (*Chrysichthys nigrodigitatus*). Length-weight regressions equations showed significant ( $p < 0.05$ ) correlation coefficients ( $r$ ) ranging between 0.4664 and 0.9949 with slopes ( $b$ ) between 2.2262 and 3.7703 corresponding to isometric, positive allometric and negative allometric growths displayed by 4, 8 and 9 species, respectively. Condition factors  $K$  varied between 0.17 - 29.38 and species with higher well-being were *Oreochromis niloticus* with  $K=29.38$ , *Hyperopisius bebe* ( $K=20.14$ ), *Coptodon zillii* ( $K=19.25$ ), *Mormyrus rume* ( $K=17.13$ ) and *Sarotherodon galilaeus multifasciatus* ( $K=16.16$ ). A sustainable exploitation of these fishes requires an ecosystem restoration scheme including habitat protection, species conservation and an ecological follow-up of the Okpara stream.

**Keywords**— Allometry, condition factor, ecosystem restoration, Northern-Benin, Oueme River.

## I. INTRODUCTION

In tropical Africa, running waters such as rivers and streams dwell a huge ichthyodiversity that is intensively exploited and constitutes an important component of the artisanal fisheries (Adite *et al.*, 2005). However, because of habitat disturbances in most African aquatic ecosystems, the growth factors of most fish species were reduced with depletion of the fish production (Adite *et al.*, 2017; FAO, 2018). In Northern Bénin, since 1969, the Okpara stream, a tributary of the Oueme River, is under various degradation pressures such as the permanent withdrawal of water by SONEB, a Company that exploits the water to satisfy domestic needs (Zogo *et al.*, 2008; Sidi Imorou *et al.*, 2019a, b). Also, the use of chemical fertilizers and pesticides for agriculture, the overfishing, the water retrieval for irrigations, the invasion of *Echhornia crassipes*, a floating plant and the introduction of *Oreochromis niloticus*, an invasive non-native fish, were some other major threats recorded on the Okpara stream.

Notwithstanding the fisheries importance of the Okpara stream in Northern-Benin, nothing is known about the growth trends of the fish fauna of this running water. Size frequency distribution, condition factors and length-weight models evaluate not only the well-being of the fishes, but also give insight on the productivity level and the “ecological health” of the ecosystems (Adeyemi, 2010; Abowei, 2010; Bolarinwa, 2016). Indeed, as reported by Adite *et al.* (2017), water quality alterations and intrusions of contaminants in the water body will negatively affect the growth and condition of fishes. Successful fisheries management require knowledge on length-weight model and condition factors that reflect the quality of the environment (Le Cren, 1951; Pauly, 1993; Ecoutin and Albaret 2003; Fiogbe *et al.*, 2003; Abowei, 2010; Ayandiran and Fawole, 2014).

The current study seeks to document length-weight patterns and condition factors of 21 dominant fish species of the Okpara stream of the Oueme River in Northern Benin in

order to evaluate their well-being and to contribute to fisheries management.

## II. MATERIALS AND METHODS

### 2.1. Study area

The current fisheries research occurred in the Okpara stream, a tributary of Oueme River of Northern Benin. Located between 8°14'- 9°45' north latitude and 2°35'- 3°25' East longitude, the Okpara stream extended on about 200 Km and belongs to the northern hydrographic network (Laleye *et al.*, 2004; Sidi Imorou *et al.*, 2019a,b). Annual temperatures averaged 26.6°C and lower temperatures, 18°C, were usually recorded in December and January. The climate is tropical with two seasons: the dry season (November to April) and the wet season (May to October). Average annual rainfall was 1200 mm with peaks (around 2100 mm) recorded in July, August and September. The soil is covered by a wooded savanna characterized by the presence of *Parkia biglobosa*, *Khaya senegalensis* and *Vitellaria paradoxa*. The vegetation also comprised Marshy meadows, bamboo and fallow bushes (Kora, 2006). The Okpara stream appeared to be the main source of revenues for the surrounding populations. Indeed, intense commercial and subsistence multi-species fisheries occurred on this stream and were practiced by grassroots and migrant fishermen. The stream also provides water for irrigated agriculture. In addition, a dam was constructed on the stream to supply the surrounding populations with drinking water (Zogo *et al.*, 2008; Sidi Imorou *et al.*, 2019a, b).

### 2.2. Sampling sites

For this study, five (05) sampling stations were selected (Sidi Imorou *et al.*, 2019a, b). Station 1 is located upstream in Perere Township. Station 2 is also situated at Okpara upstream in Gadela village at Parakou Township, about 2 km from SONEB dam (Sidi Imorou *et al.*, 2019a, b). Station 3 is located at Kpassa village, around SONEB dam that serves as a source of drinking water for the surrounding populations. Station 4 is located around Okpara downstream in Yarimrou village at Tchaourou Township. Site 5 is also located around Okpara downstream, but at Sui village of Tchaourou Township (Fig. 1). At each fish collection station, two habitats, the aquatic vegetation and the open water were sampled.

### 2.3. Fish collection

Fish samplings were done once a month for eighteen (18) months (December 2015-May 2017) in all sampling sites and

habitats (open water, aquatic vegetation). Experimental samplings were done with gillnets (25 m x 1.30 m, 30 mm-mesh; 25 m x 1.30 m, 15 mm-mesh), hawk and seine (4.20 m-length, 2 m – width, 5 mm-mesh) to get juveniles, sub-adults and adults (Sidi Imorou *et al.* 2019a, b). Catches from artisanal fisheries were supplemented to get the population sample of each species. Thus, for each species, one third of the fisherman capture was sampled (Okpeicha, 2011; Adite, 2007; Sidi Imorou *et al.*, 2019a, b). After collection, the fishes were first identified in situ, preserved in a cooler and transported to the “Laboratoire d’Ecologie et de Management des Ecosystèmes Aquatiques” to confirm identifications. References such as Levêque *et al.* (1990; 1992), Paugy *et al.* (2004) and Lévêque and Paugy (2006) were used for identifications. Fish scientific names have been confirmed on [www.Fishbase.org](http://www.Fishbase.org) (Froese and Pauly, 2018). In the laboratory, each individual was measured for total length (TL) and standard length (SL) to the nearest 0.1 cm and weighted to the nearest 0.1g using respectively an ichthyometer and an electronic scale (Sidi Imorou *et al.*, 2019 a, b). The specimens were then preserved in 10% formalin and latter in 70% ethanol (Murphy and Willis, 1996).

### 2.4. Data analysis

Total length (TL), standard length (SL) and weight (W) data of each fish individual were recorded in Excel 2017 spreadsheet along with sampling dates and sampling sites. The size structures (frequency histograms) of dominant fishes were constructed for the whole population. Le Cren's (1951) model was used to establish the length-weight relationship of fishes:

$$W = aTL^b \quad (\text{Le Cren, 1951}),$$

Where, **W** is the total weight (g), **TL** the total length (cm), **a**, the intercept and **b** the allometry coefficient (Le Cren, 1951). The Student T-test was used to compare the value of the slope “**b**” with 3. The test was significant when  $p < 0.05$ . SPSS package Software version 21 (Morgan *et al.*, 2001) was used to perform the regression analysis. The adaptation to the environmental conditions was evaluated by the Tesch's (1971) condition factor:

$$K = 100 * W / TL^b$$

Where, **K** is the condition factor, **W** is the total weight (g) and **TL** the total length (cm).

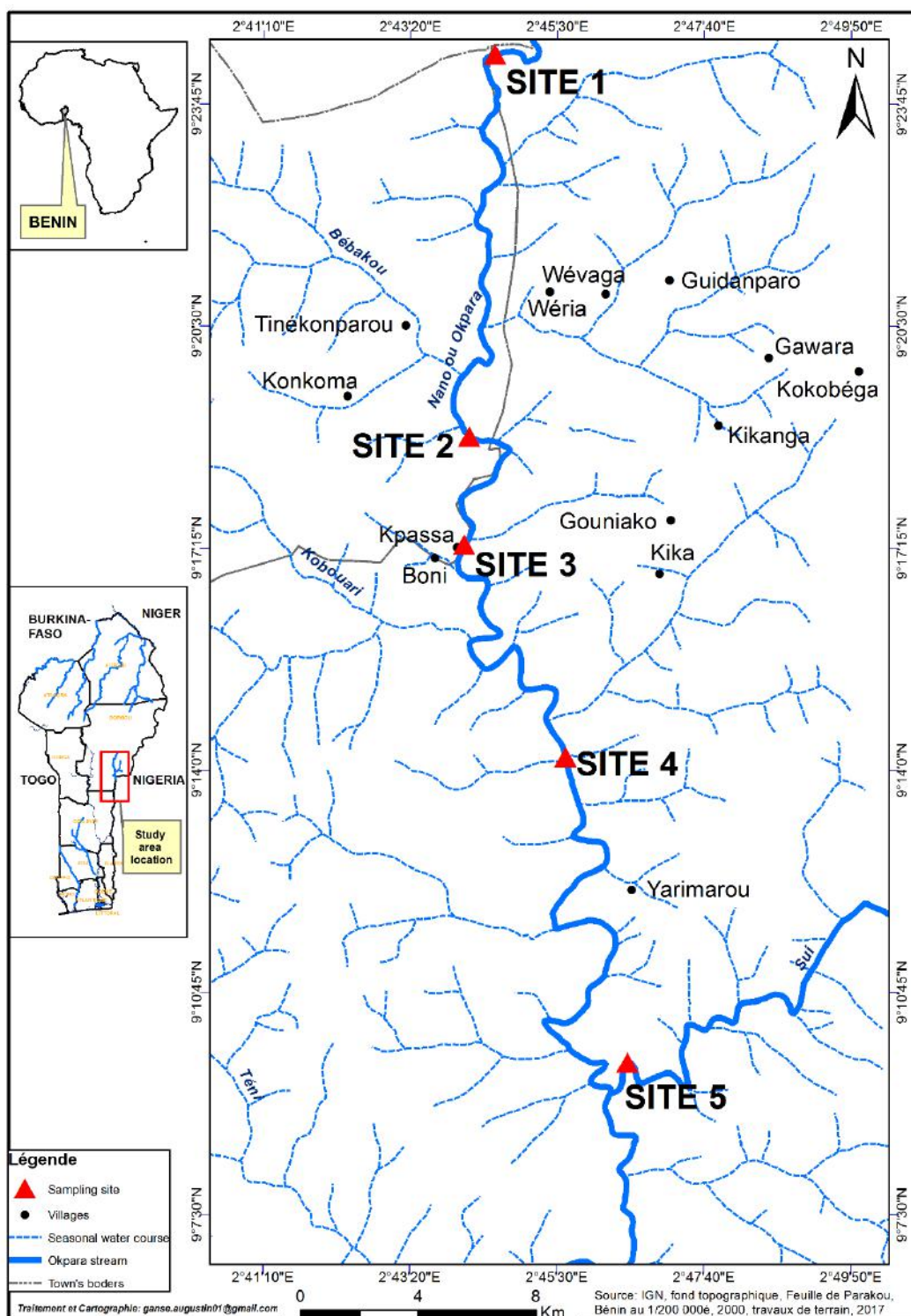


Fig.1: Okpara stream and sampling sites. Site 1= Perere Township, Site 2 = Gadela village (Parakou Township), Site 3= Kpassa village (Tchaourou Township), Site 4= Yarimarou village (Tchaourou Township), Site 5 = Sui village (Tchaourou Township).

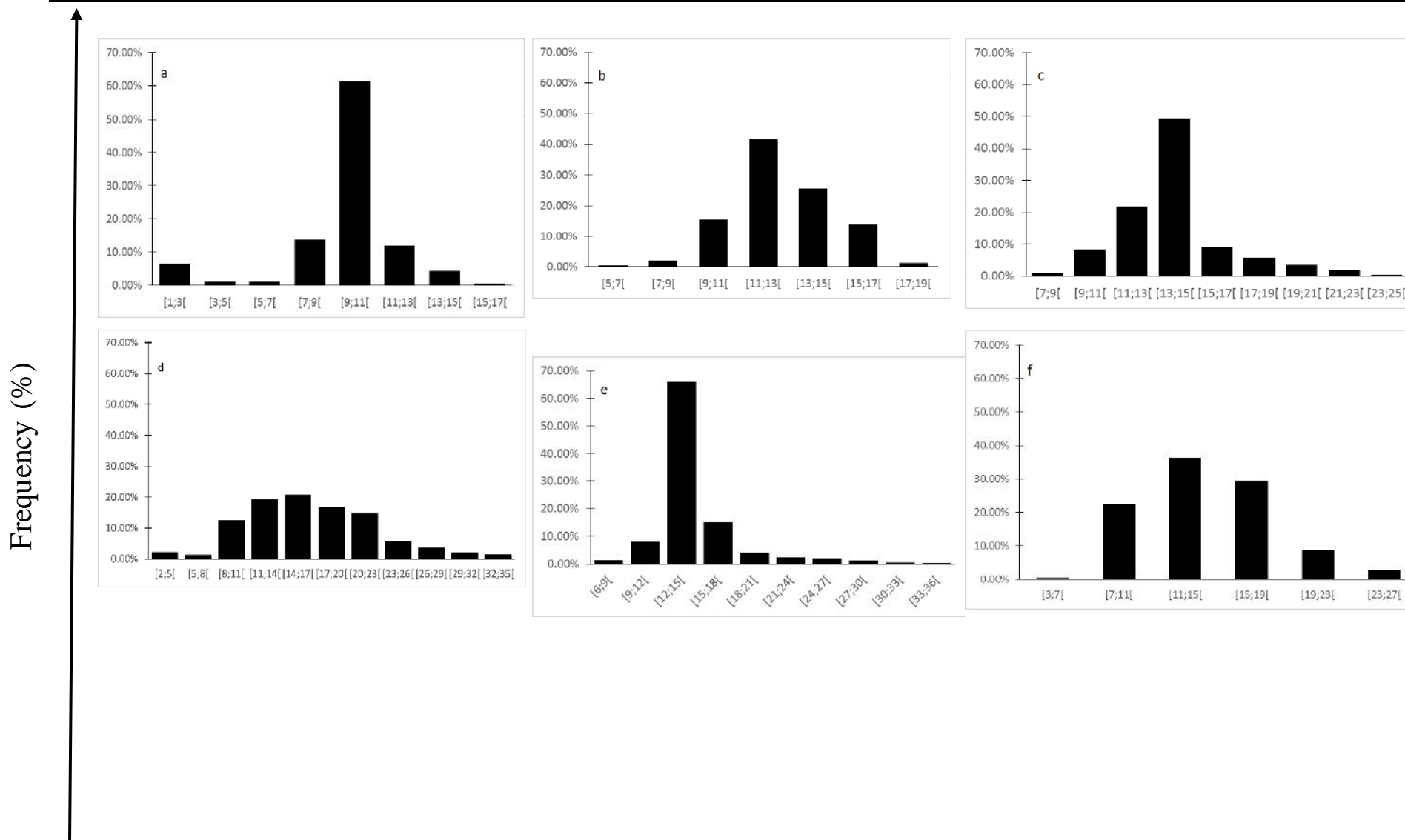
### III. RESULTS

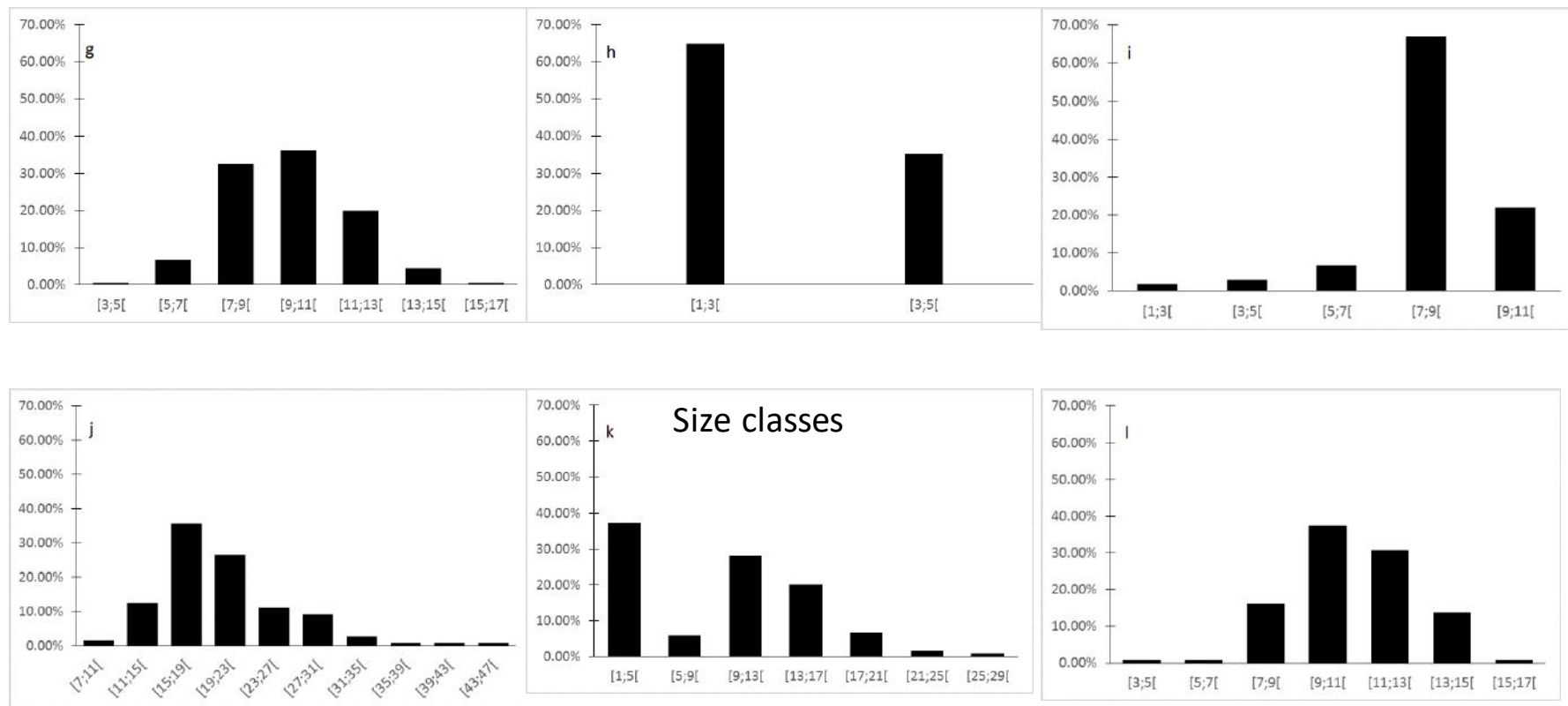
#### 3.1. Species abundance

During this fisheries survey, a total of 9552 fish individuals comprising 53 species belonging to 28 genera and 15 families were sampled. Mormyrids (9 species) and Cichlids (8 species) were the most represented taxa and numerically dominated the Okpara stream fish community with 19.49% and 44.82%, respectively. Other common families were Alestidae, Aplocheilidae, Bagridae, Clariidae, Claroteidae, Cyprinidae, Hepsetidae, Moxokidae, Schilbeidae, Polypteridae, Anabantidae and Malapteruridae. Dominant species included the piscivorous cichlid, *Hemichromis fasciatus* (29.20%), the mormyrid *Marcusenius senegalensis* (16.27%), *Schilbe intermedius* (10.34%), the Nile tilapia, *Oreochromis niloticus* (9.84%) and the characid *Brycinus macrolepidotus* (9.14%). The less speciose families with only one species were Hepsetidae represented by *Hepsetus odoe* and Aplocheilidae represented by *Epiplatys bifasciatus*. In the current fisheries study, size distribution, length-weight models and condition factors has been performed for the first 21 dominant species of abundance more than fifty (50) individuals, belonging to 11 families, 15 genus, and totalizing about 9,305 specimens (Table1).

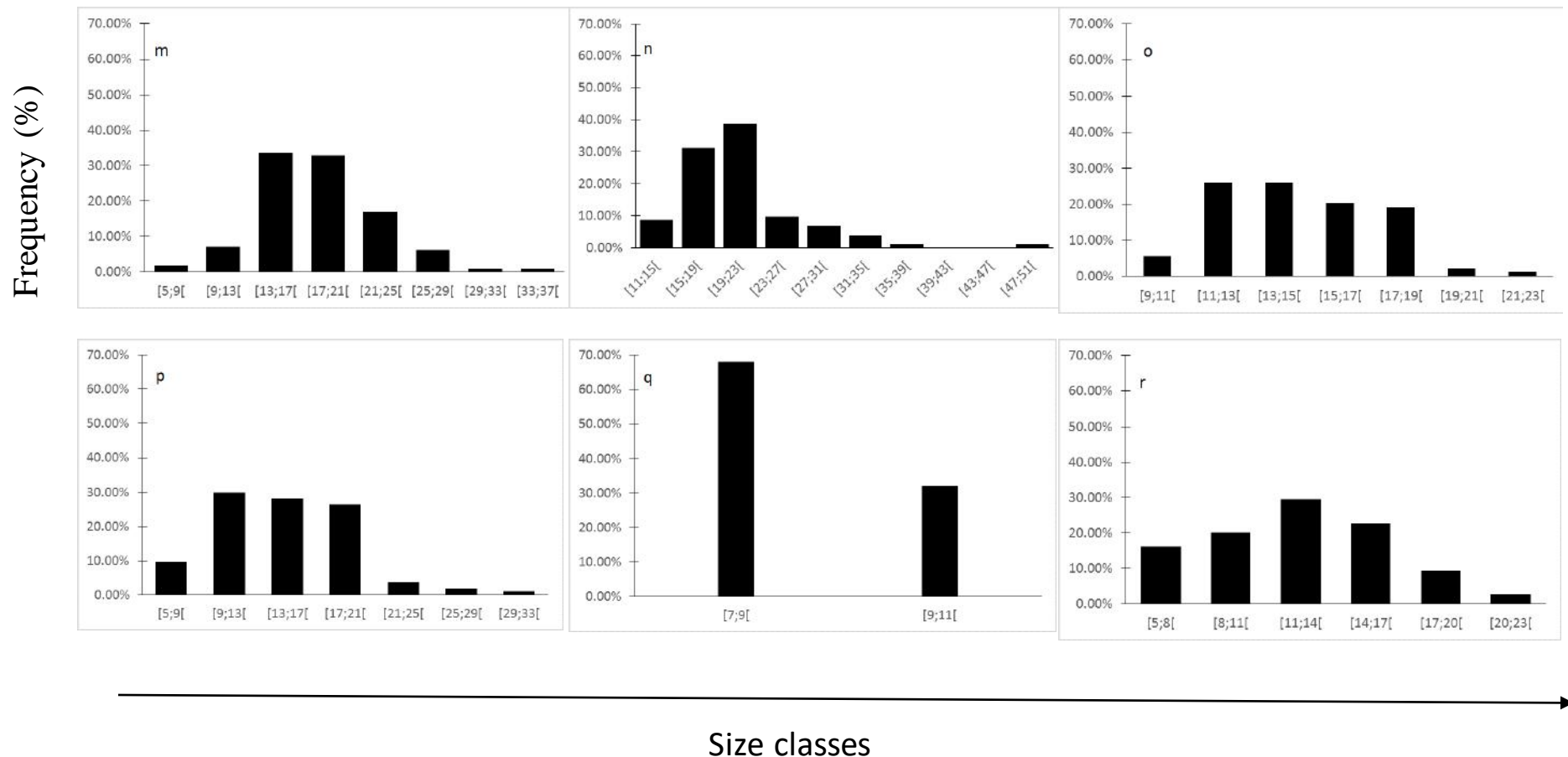
#### 3.2. Size structures

When considering the 21 dominant species of the fish assemblages, sample sizes ranged from 53 (0.55%) for *Mormyrus rume* to 2,818 (29.49%) for *Hemichromis fasciatus*. Among the 21 species, standard length (SL) varied from 1.2 cm (*Coptodon guineensis*) to 51.8 cm (*Chrysichthys nigrodigitatus*), and the weight ranged between 0.02g (*Epiplatys bifasciatus*) and 1,346g (*Hepsetus odoe*). Species exhibiting larger sizes ( $\geq 200$  mm) included *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Coptodon guineensis*, *Coptodon zillii*, *Clarias gariepinus*, *Hepsetus odoe*, *Chrysichthys nigrodigitatus*, *Hyperopisius bebe*, *Mormyrus rume*, *Labeo parvus*, *Brycinus macrolepidotus*, *Synodontis schall* and *Schilbe intermedius* (Table 1).









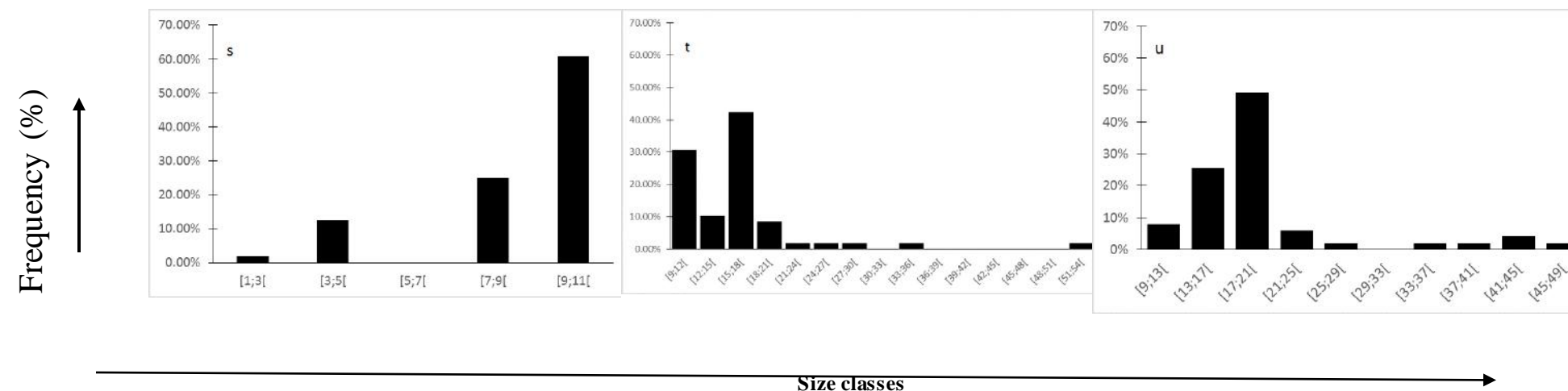


Fig. 2: Size structure of Okpara Stream fishes: a = *Hemichromis fasciatus*; b = *Marcusenius senegalensis*; c = *Schilbe intermedius*; d = *Oreochromis niloticus*; e = *Brycinus macrolepidotus*; f = *Synodontis schall*; g = *Chromidotilapia guntheri*; h = *Epiplatys bifasciatus*; i = *Enteromius macrops*; j = *Clarias gariepinus*; k = *Coptodon guineensis*; l = *Ctenopoma petherici*; m = *Hyperopisius bebe*; n = *Hepsetus odoe*; o = *Labeo parvus*; p = *Sarotherodon galileus multifasciatus*; q = *Petrocephalus bovei*; r = *Coptodon zillii*; s = *Enteromius callipterus*; t = *Chrysichthys nigrodigitatus*; u = *Mormyrus rume*

### 3.3. Length-weight relationships

Table 1 shows the matrix of length-weight regression equations of the 21 dominant species along with associated correlation coefficients ( $r$ ), allometric coefficients  $b$  and constants  $a$ . Overall, the coefficients of correlation ( $r$ ) ranged between 0.4664 (*Barbus macrops*) and 0.9949 (*Coptodon guineensis*), and the allometric coefficients ( $b$ ) varied from 2.2262 (*Barbus macrops*) to 3.7703 (*Petrocephalus bovei*) with a mean value of  $3.012 \pm 0.3885$  (Figure 1). This mean value of  $b$  was not statistically different from the theoretical value 3 ( $df = 20$ ,  $p = 0.888$ ). The distribution of  $b$  value in Okpara Stream (Figure 2) followed a normal distribution (Ryan-Joiner normality test:  $p > 0.05$ ). Analysis of the allometric coefficients  $b$  revealed that four (4) species *Hemichromis fasciatus*, *Coptodon guineensis*, *Sarotherodon galilaeus multifasciatus* and *Barbus callipterus* showed an isometric growth ( $b = 3$ ;  $p > 0.05$ ). Species like *O. niloticus*, *C. gariepinus*, *H. odoe*, *C. petherici*, *C. nigrodigitatus*, *P. bovei*, *L. parvus*, *E. bifasciatus* exhibited positive allometric coefficients ( $b > 3$ ;  $p < 0.05$ ) (Table 1). Negative allometric growth ( $b < 3$ ;  $p < 0.05$ ) were recorded for species like *C. guntheri*, *C. zillii*, *M. senegalensis*, *H. bebe*, *M. rume*, *B. macrops*, *B. macrolepidotus*, *S. schall* and *S. intermedius*.



TABLE 1: Length-weight relationships parameters of the 21 dominant fish species collected from Okpara Stream, Oueme River between December 2015 and May 2017

Species	N	Total Length (cm)		Weight (g)		Length-Weight Relationship					
		Min	Max	Min	Max	a	b	SE (b)	r	Growth	T-test
<b>Cichlidae</b>											
<i>Hemichromis fasciatus</i>	2818	1.4	15.5		88.3	0.0167	3.0024	0.00246	0.9716	I	p =0.199
<i>Oreochromis niloticus</i>	950	2.8	33.6	0.6	909	0.0179	3.0585	0.00260	0.9608	A+	p =0.000
<i>Chromidotilapia guntheri</i>	228	4	15.9	1.24	62.14	0.0205	2.9823	0.00361	0.9633	A-	p =0.000
<i>Coptodon guineensis</i>	138	1.2	26	0.4	285.4	0.0194	3.0151	0.0235	0.9949	I	p =0.653
<i>Sarotherodon galileus multifasciatus</i>	132	1.2	29	0.1	591	0.0142	3.1406	0.0820	0.9904	I	p =0.058
<i>Coptodon zillii</i>	80	6.5	20.4	5.1	203.4	0.0342	2.7581	0.0106	0.9147	A-	p =0.000
<b>Clariidae</b>											
<i>Clarias gariepinus</i>	155	7.1	46	3.02	676	0.0058	3.0591	0.00586	0.9277	A+	p =0.000
<b>Hepsetidae</b>											
<i>Hepsetus odoe</i>	109	6.5	47.6	3.22	1346	0.0013	3.5604	0.00754	0.9366	A+	p =0.000
<b>Anabantidae</b>											
<i>Ctenopoma petherici</i>	118	4.1	15.3	1.24	87.7	0.0148	3.1592	0.00342	0.9811	A+	p =0.000
<b>Claroteidae</b>											
<i>Chrysichthys nigrodigitatus</i>	59	9.2	51.8	5.8	214.2	0.0083	3.0347	0.00624	0.975	A+	p =0.000
<b>Mormridae</b>											
<i>Marcusenius senegalensis</i>	1570	1.6	18.5	1.46	72.2	0.0114	2.9479	0.00140	0.9198	A-	p =0.000
<i>Hyperopisius bebe</i>	117	6.7	33.9	4.6	233	0.049	2.2522	0.0118	0.7884	A-	p =0.000
<i>Petrocephalus bovei</i>	81	7.3	9.9	4.52	12.2	0.0023	3.7703	0.00887	0.6782	A+	p =0.000
<i>Mormyrus rume</i>	53	9	45.3	4.3	696	0.009	2.8816	0.0194	0.8955	A-	p =0.000
<b>Cyprinidae</b>											
<i>Enteromius macrops</i>	179	2.7	10.1	0.22	13.4	0.0645	2.2262	0.0172	0.4664	A-	p =0.000
<i>Enteromius callipterus</i>	64	2.6	10.3	0.38	14.36	0.0138	3.0003	0.0208	0.9667	I	p =0.905
<i>Labeo parvus</i>	91	9.2	21.4	5.38	108.86	0.0023	3.5348	0.00469	0.9688	A+	p =0.000
<b>Alestidae</b>											
<i>Brycinus macrolepidotus</i>	882	6.5	33.5	3.22	509	0.0151	2.8947	0.00174	0.9397	A-	p =0.000
<b>Aplocheilidae</b>											
<i>Epiplatys bifasciatus</i>	207	1.6	4.1	0.02	0.62	0.0041	3.5821	0.0244	0.7842	A+	p =0.000
<b>Mockokidae</b>											
<i>Synodontis schall</i>	276	3.3	26.3	4.52	257.1	0.0191	2.7612	0.00818	0.9362	A-	p =0.000
<b>Schilbeidae</b>											
<i>Schilbe intermedius</i>	998	7.4	25.3	6.66	184.7	0.0198	2.6325	0.00239	0.8517	A-	p =0.000

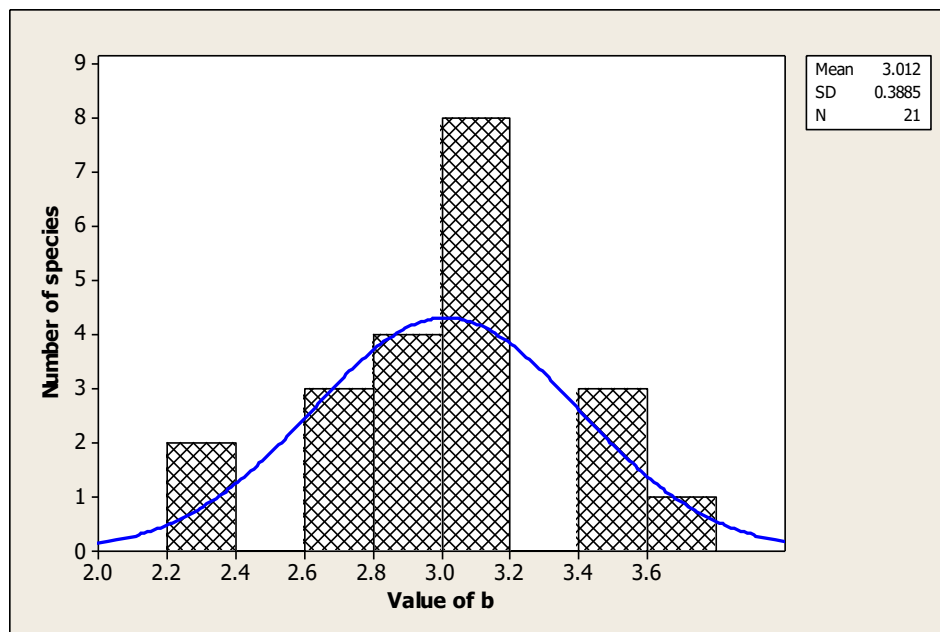


Fig. 3: Distribution of the slopes  $b$  (allometric coefficients) of the 21 dominant fish species collected from Okpara Stream, Oueme River between December 2015 and May 2017

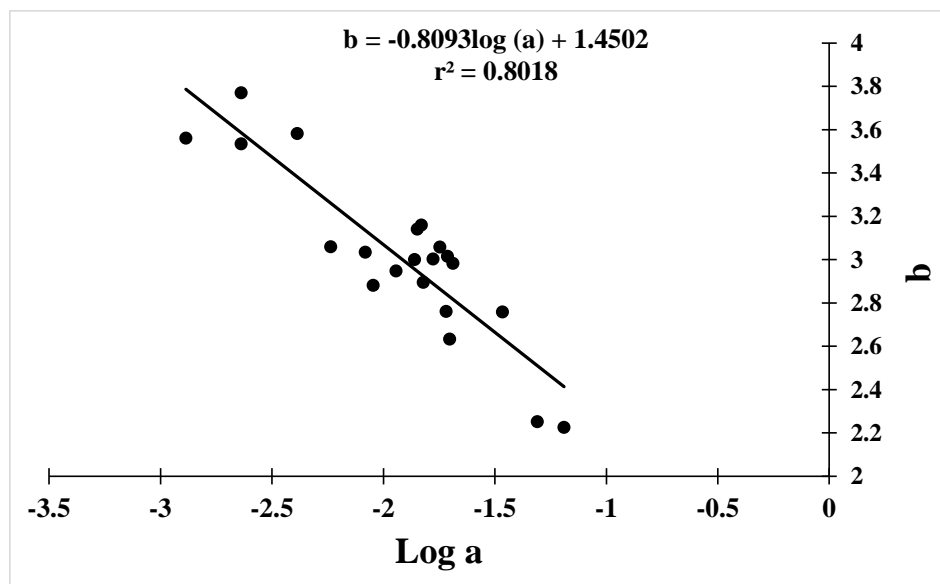


Fig. 3: Regression of  $\log(a)$  and  $b$  of the length-weight relationship of the 21 dominant fish species collected from Okpara Stream, Oueme River between December 2015 and May 2017

Also, the relationship between the allometric coefficients  $b$  and the logarithm of the intercept  $a$  gave the equation:  $b = -0.8093 * \log(a) + 1.4502$  ( $r^2 = 0.8018$ ), indicating that as the slope  $b$  increases, the intercept  $a$  increases (Fig. 3).

TABLE 2: Length-weight relationships parameters for most dominant fishes of Okpara stream by seasons

Species	Dry				Wet				Flood			
	a	b	r	growth	a	b	R	growth h	a	b	r	growth
<i>Hemichromis fasciatus</i>	0.02	2.9257	0.99	A**	0.0163	2.9958	0.98	I	0.0066	3.4094	0.95	A**+
<i>Marcusenius senegalensis</i>	0.0637	2.2568	0.82	A**	0.4315	1.5247	0.63	A**	0.0069	3.152	0.93	A**+
<i>Schilbe intermedius</i>	0.0108	2.8444	0.91	A**	0.2687	1.6402	0.82	A**	0.006	3.0933	0.97	A**+
<i>Oreochromis niloticus</i>	0.0184	3.0628	0.98	A**+	0.0177	3.0374	0.99	A**+	0.0150	3.2935	0.97	A**+
<i>Brycinus macrolepidotus</i>	0.0142	2.9169	0.97	A**	0.0226	2.7452	0.91	A**	0.0026	2.8425	0.91	A**
<i>Synodontis schall</i>	0.0286	2.5953	0.95	A**	0.0144	2.8635	0.96	A**	0.0010	3.0015	0.93	A**+
<i>Chromidotilapia guntheri</i>	0.0409	2.6544	0.93	A**	0.0234	2.8715	0.98	A**	0.0226	3.0798	0.92	A**+
<i>Epiplatys bifasciatus</i>	0.0135	2.6439	0.88	A**	0.0058	3.3368	0.90	A**+	-	-	-	-
<i>Enteromius macrops</i>	0.1621	1.7433	0.68	A**	0.0049	3.5052	0.81	A**+	0.0026	3.213	0.88	A**+
<i>Clarias gariepinus</i>	0.008	2.9475	0.94	A**	0.0033	3.2505	0.99	A**+	0.0045	3.2041	0.96	A**+
<i>Coptodon guineensis</i>	0.0297	2.8325	0.97	A**	0.0193	3.0146	0.99	I	-	-	-	-
<i>Sarotherodon galileus multifasciatus</i>	0.0228	2.9410	0.96	I	0.012	3.1964	0.99	A**+	0.0251	2.9449	0.90	I
<i>Ctenopoma petherici</i>	0.0123	3.2445	0.99	A**+	0.0186	3.0421	0.99	A**+	0.1729	2.2248	0.96	A**
<i>Hyperopisius bebe</i>	0.0125	2.6950	0.96	A**	0.0063	2.9431	0.99	A**	-	-	-	-
<i>Hepsetus odoe</i>	0.006	3.0387	0.86	A**+	0.0022	3.4443	0.99	A**+	0.0015	3.5786	0.87	A**+
<i>Labeo parvus</i>	0.0025	3.4852	0.98	A**+	0.0073	3.1172	0.99	A**+	0.0024	3.4021	0.91	A**+
<i>Petrocephalus bovei</i>	0.0023	3.7680	0.83	A**+	1.24	1.3053	0.95	A**	-	-	-	-
<i>Coptodon zillii</i>	0.0292	2.8906	0.96	A**	0.0108	3.108	0.95	A**+	-	-	-	-
<i>Enteromius callipterus</i>	-	-	-	-	0.0135	3.005	0.91	I	0.0263	2.7187	0.92	A**
<i>Chrysichthys nigrodigitatus</i>	0.0343	2.5789	0.79	A**	0.0036	3.3592	0.99	A**+	0.0013	3.5081	0.94	A**+
<i>Mormyrus rume</i>	0.0024	3.3065	0.99	A**+	0.4971	1.3913	0.96	A**	-	-	-	-

\*\* p&lt;0.001; \* p&lt;0.05

### 3.2. Condition factors

The condition factors (K) of fishes from Okpara stream varied between species ( $F_{20,8545}=259.543$ ;  $p<0.05$ ). In this survey, K ranged between 0.17 (*Epiplatys bifasciatus*) and 29.38 (*Oreochromis niloticus*) with a mean of  $11.93 \pm 6.49$ . Four (4) species, *Epiplatys bifasciatus*, *Petrocephalus bovei*, *Labeo parvus* and *Barbus callipterus* of cumulated abundance 4.76%, showed weak condition factors K ranging between 0.17 and 8. Also, moderate K varying between 8 and 15 were recorded for 12 species (80.92%), *Hemichromis*

*fasciatus*, *Marcusenius senegalensis* *Schilbe intermedius* *Chromidotilapia guntheri* *Synodontis schall* *Brycinus macrolepidotus*, *Barbus macrops*, *Clarias gariepinus*, *Coptodon guineensis*, *Ctenopoma petherici*, *Hepsetus odoe*, *Chrysichthys nigrodigitatus*. Only five (5) species (14.32%), *Oreochromis niloticus*, *Sarotherodon galilaeus* *mustifasciatus*, *Mormyrus rume*, *Hyperopisius bebe* and *Coptodon zillii* exhibited a relatively higher condition factors K that varied between 16.16 and 29.38 (Table 3).

TABLE 3: Condition factors (K) of the 21 dominant fish species collected from Okpara Stream, Oueme River between December 2015 and May 2017

Species	Sample size	K
<i>Hemichromis fasciatus</i>	2818	8.02
<i>Marcusenius senegalensis</i>	1570	8.61
<i>Schilbe intermedius</i>	998	10.65
<i>Oreochromis niloticus</i>	950	29.38
<i>Brycinus macrolepidotus</i>	882	14.53
<i>Synodontis schall</i>	276	14.21
<i>Chromidotilapia guntheri</i>	228	9.44
<i>Epiplatys bifasciatus</i>	207	0.17
<i>Barbus macrops</i>	179	9.47
<i>Clarias gariepinus</i>	155	14.30
<i>Coptodon guineensis</i>	138	11.66
<i>Sarotherodon galilaeus multifasciatus</i>	132	16.16
<i>Ctenopoma petherici</i>	118	11.0
<i>Hyperopisius bebe</i>	117	20.14
<i>Hepsetus odoe</i>	109	10.79
<i>Labeo parvus</i>	91	6.34
<i>Petrocephalus bovei</i>	81	2.01
<i>Coptodon zillii</i>	80	19.25
<i>Barbus callipterus</i>	64	5.21
<i>Chrysichthys nigrodigitatus</i>	59	12.05
<i>Mormyrus rume</i>	53	17.13

TABLE 4: Condition factors (K) of the 21 dominant fish species collected from Okpara Stream, Oueme River between December 2015 and May 2017 by seasons

Species	K $\pm$ SD		
	Dry	Wet	Flood
<i>Hemichromis fasciatus</i>	8.41 $\pm$ 3.38 <sup>b</sup>	7.50 $\pm$ 2.12 <sup>a</sup>	11.35 $\pm$ 2.36 <sup>c</sup>
<i>Marcusenius senegalensis</i>	16.06 $\pm$ 4.13 <sup>b</sup>	16.44 $\pm$ 7.68 <sup>b</sup>	10.41 $\pm$ 2.60 <sup>a</sup>
<i>Schilbe intermedius</i>	7.67 $\pm$ 2.11 <sup>a</sup>	9.25 $\pm$ 3.07 <sup>a</sup>	10.86 $\pm$ 3.38 <sup>b</sup>
<i>Oreochromis niloticus</i>	30.98 $\pm$ 21.23 <sup>b</sup>	31.83 $\pm$ 23.11 <sup>b</sup>	10.53 $\pm$ 4.98 <sup>a</sup>
<i>Brycinus macrolepidotus</i>	14.61 $\pm$ 8.78	14.24 $\pm$ 3.54	13.95 $\pm$ 4.61
<i>Synodontis schall</i>	13.15 $\pm$ 9.10	13.45 $\pm$ 6.26	12.01 $\pm$ 6.84
<i>Chromidotilapia guntheri</i>	12.38 $\pm$ 4.76 <sup>c</sup>	7.66 $\pm$ 1.70 <sup>a</sup>	9.21 $\pm$ 2.76 <sup>b</sup>

<i>Epiplatys bifasciatus</i>	0.53±0.12 <sup>b</sup>	0.31±0.10 <sup>a</sup>	-
<i>Enteromius macrops</i>	13.47±3.0 <sup>c</sup>	3.18±1.25 <sup>a</sup>	8.54±2.61 <sup>b</sup>
<i>Clarias gariepinus</i>	16.65±10.0 <sup>c</sup>	13.59±3.82 <sup>b</sup>	9.25±2.54 <sup>a</sup>
<i>Coptodon guineensis</i>	21.93±11.02 <sup>b</sup>	4.36±8.22 <sup>a</sup>	-
<i>Sarotherodon galilaeus multifasciatus</i>	20.33±15.33	19.26±10.85	19.52±31
<i>Ctenopoma petherici</i>	9.27±2.98 <sup>a</sup>	12.41±4.69 <sup>b</sup>	12.02±2.36 <sup>b</sup>
<i>Hyperopisius bebe</i>	12.94±7.0 <sup>b</sup>	8.58±3.32 <sup>a</sup>	-
<i>Hepsetus odoe</i>	17.79±19.88 <sup>b</sup>	18.79±13.85 <sup>b</sup>	10.26±4.90 <sup>a</sup>
<i>Labeo parvus</i>	5.34±2.54 <sup>a</sup>	12.56±2.79 <sup>b</sup>	10.51±2.14 <sup>b</sup>
<i>Petrocephalus bovei</i>	2.00±0.41 <sup>a</sup>	5.23±0.70 <sup>b</sup>	-
<i>Coptodon zillii</i>	23.03±9.93 <sup>b</sup>	15.24±8.71 <sup>a</sup>	-
<i>Enteromius callipterus</i>	-	5.87±0.64 <sup>a</sup>	7.90±0.75 <sup>b</sup>
<i>Chrysichthys nigrodigitatus</i>	26.73±15.61 <sup>c</sup>	6.13±3.78 <sup>a</sup>	12.95±5.20 <sup>b</sup>
<i>Mormyrus rume</i>	8.04±6.66 <sup>a</sup>	38.86±1.80 <sup>b</sup>	-

<sup>abc</sup> Mean with different letters are statistically different (p < 0.05)

#### IV. DISCUSSION

Anthropogenic disturbances such as the withdrawal of water for irrigation and domestic uses, the use of chemical fertilizers and pesticides for agriculture, the proliferation of floating plants etc. appeared to be the major degradation factors that affect water quality, abundance and growth of the fishes from Okpara Stream, a tributary of the Oueme River in Northern-Benin (Adite *et al.*, 2017; FAO, 2018). The current study analyses size structures, length-weight relationships and condition factors of the 21 dominant fish species of Okpara Stream (Table 1). Overall, the results consistently showed a high length variability between and within populations (Figure 2 and Table 1). Compared to other African water bodies under intense fisheries exploitation, the maximum total length, TL<sub>m</sub>=15.5 cm, recorded for the dominant species *Hemichromis fasciatus* agreed with that reported by Kamelan *et al.* (2014) in the Tai national Park of Ivory Coast. In contrast, the TL<sub>m</sub> recorded for this predator was higher than those reported by Tossavi (2011) in Lake Toho (TL<sub>m</sub>=9.1 cm) and by Adite and Fiogbe (2013) in the Mono River (TL<sub>m</sub>=14.2 cm), both ecosystems located in Southern Benin. Inversely, the maximum size recorded for *H. fasciatus* was lower than those reported by Hazoume *et al.* (2017) in the Sô River (TL<sub>m</sub>=19.1 cm) in Benin and by Ecoutin and Albaret (2003) in the Ebrie Lagoon (TL<sub>m</sub>=23 cm) in Ivory Coast. Overall, the differential abundances of preys available for this top piscivore and the conditions of these habitats may explain the spatial variabilities of the growth patterns displayed (Adite *et al.*, 2017).

In this study, in general, species such as *Mormyrus rume*, *Brycinus macrolepidotus*, *Clarias gariepinus*, *Synodontis schall*, *Hemichromis fasciatus*, *Oreochromis*

*niloticus*, *Sarotherodon galilaeus*, *Chrysichthys nigrodigitatus* and *Hepsetus odoe* exhibited lower size (TL<sub>m</sub>) compared to those reported in the Mono river, in the Tai national Park, in the traditional fishponds ("whedo") of the Oueme River, in Lake Toho and in the Sô river (Tossavi, 2011; Adjibade, 2013; Adite and Fiogbe, 2013; Kamelan *et al.*, 2014; Hazoume *et al.*, 2017). In contrast, cichlids such as *Chromidotilapia guntheri* and *Coptodon guineensis* showed lower sizes compared to individuals from Lake Toho (Tossavi, 2011) and from the Mono river (Adite and Fiogbe, 2013), respectively. Nevertheless, the TL<sub>m</sub> of the exotic invasive cichlid, *Oreochromis niloticus* (TL<sub>m</sub>=33.60 cm) agreed with those reported by Tossavi (2011) in Lake Toho and by Hazoume *et al.* (2017) in the Sô River. These spatial variabilities in fish sizes were the results of habitat conditions, mainly water quality, food availability and the level of habitat degradation. In general, total length (TL) frequency histograms established for the 21 dominant fishes exhibited an unimodal size distribution for 17 species. In contrast, 4 species, *Coptodon guineensis*, *Enteromius callipterus*, *Chrysichthys nigrodigitatus* and *Mormyrus rume* showed a bimodal size distribution (Figure 2).

In this stream, the fishes examined showed a high variability in length-weight models with allometric coefficients (*b*) varying between 2.226 for *Enteromius macrops* (Cyprinidae) and 3.770 for *Petrocephalus bovei* (Mormyridae) with highly correlation coefficients (*r*) ranging between 0.91 and 0.99. Overall, the student T-test indicated that 13 species out of 21 showed positive growth trends. Indeed, four (4) species, *Hemichromis fasciatus*, *Coptodon guineensis*, *Sarotherodon galilaeus multifasciatus* and *Enteromius callipterus* exhibited an isometric growth

with  $b$  approximating 3, suggesting that these fishes displayed identical length and weight growth rates (Deekae and Abowei, 2010; Kuriakose, 2014). Also, eight (8) species, *Oreochromis niloticus*, *Clarias gariepinus*, *Hepsetus odoe*, *Ctenopoma petherici*, *Chrysichthys nigrodigitatus*, *Petrocephalus bovei*, *Epiplatys bifasciatus* and *Labeo parvus* showed significant ( $p < 0.05$ ) positive allometric growth with slopes  $b > 3$ , indicating that the fish became more rotund as total length increased (Deekae and Abowei, 2010; Kuriakose, 2014). This favorable growth patterns probably result from their high tolerance to degrading habitat conditions. Inversely, nine (9) fishes, *Chromidotilapia guntheri*, *Coptodon zillii*, *Marcusenius senegalensis*, *Hyperopisius bebe*, *Mormyrus rume*, *Enteromius macrops*, *Brycinus macrolepidotus*, *Synodontis schall* and *Schilbe intermedius* probably less tolerant, showed significant ( $p < 0.05$ ) negative allometric growth with slopes  $b$  less than 3, indicating that these fishes became less rotund as total length increased (Kuriakose, 2014).

In particular, the growth pattern of some large and tolerant fishes such *Sarotherodon galilaeus multifasciatus* and *Clarias gariepinus* agreed with those reported by Tossavi (2011) in Lake Toho and by Adjibade (2013) in the Oueme River where these species exhibited an isometric growth and a positive allometric growth, respectively. Nevertheless, *C. gariepinus* exhibited a negative allometric growth in Ikpoba River in Nigeria (Omatsuli *et al.*, 2017). Unlike the current findings, the large fishes, *Oreochromis niloticus* and *Chrysichthys nigrodigitatus* exhibited a negative allometric growth in the Mono River in Benin (Adite and Fiogbe, 2013) and in the Tai national Park of Ivory Coast (Kamelan *et al.*, 2014) probably because of habitat disturbances. Also, unlike the isometric growth exhibited by the dominant species *H. fasciatus* in this study, Ecoutin and Albaret (2003), Kamelan *et al.* (2014) and Hazoume *et al.* (2017) reported positive allometric growth in the Ebrie Lagoon, in the Tai national Park and in the Sô River, respectively, indicating that this predator showed a relatively high well-being, probably because of suitable habitat conditions coupled with an efficient predation strategy. As reported by Bagenal (1978), Adite *et al.* (2017) and Lederoun *et al.* (2018), habitat conditions and stochasticity, food resource availabilities, unbalanced ecosystems and fish species tolerance to critical habitat factors could favor the differential growth pattern recorded.

Seasonally, because flooding brought substantial food resources to fishes, the slopes were higher and ranged between 2.225 (*Ctenopoma petherici*) and 3.578 (*Hepsetus*

*odoe*) with twelve (12) species showing positive allometric growth against only three (3) species, *Ctenopoma petherici*, *Brycinus macrolepidotus* and *Enteromius callipterus* that exhibited significant ( $p < 0.05$ ) negative allometric growth. In contrast, the dry and wet seasons with relatively moderate food resources, comprised high percentage of species, 65% and 54%, respectively that exhibited negative allometric growth.

In this fisheries survey, condition factors (K) were moderate and ranged between 0.17 for *Epiplatys bifasciatus* and 29.38 for the invasive Nile tilapia, *Oreochromis niloticus*. In general the condition factors recorded in this study were higher than those reported by Kamelan *et al.* (2014) for *Hemichromis fasciatus*, *Chrysichthys nigrodigitatus*, *Chromidotilapia guntheri*, *Brycinus macrolepidotus*, *Hepsetus odoe* and *Mormyrus rume* in the Tai national Park of Ivory Coast. Likewise, values of K for *Hepsetus odoe* and *Ctenopoma petherici* in this study were higher than those reported by Adjibade (2013) in the traditional fishponds ("whedo") of the Oueme River. Also, the introduced invasive cichlid, *Oreochromis niloticus* displayed a higher well-being in the Okpara stream compared to individuals reported by Omatsuli *et al.* (2017) in Ikpoba River in Nigeria and those reported by Adite *et al.* (2017) in Lake Toho in the Southern Benin, probably because of differential habitat conditions. Nevertheless, in the Okpara stream, the common African catfish, *C. gariepinus*, showed lower  $K=14.30$  compared to individual reported by Adjibade (2013) in the traditional fish ponds ("whedo") known as highly productive (Imorou Toko *et al.*, 2013). According to Richter (2007) and Abowei (2009), combined factors such as seasonal variabilities, habitat conditions, food availability, ontogeny and sexual stage of maturation could act to affect the level of K and the well-being of the fishes (Le Cren, 1951; Pauly, 1993; Ayandiran and Fawole 2014).

## V. CONCLUSIONS

Though under multiple degradation factors, some dominant fishes of the Okpara stream showed higher well-being indicated by an isometric growth and a positive allometric growth for more than half of the sub-community. However, the nine (9) less tolerant species that showed a negative allometric growth reflected the impacts of habitat disturbances and fragmentations. A sustainable exploitation of this fish fauna requires an ecosystem restoration plan including habitat protection, species conservation, an eco-management of the fisheries and a periodic bio-ecological follow-up of the Okpara stream.



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